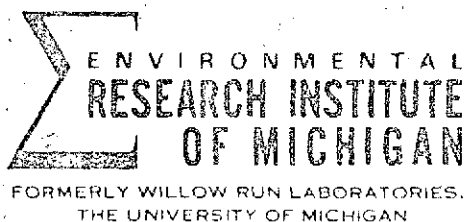# EXTENSION OF ERIM MULTISPECTRAL DATA PROCESSING CAPABILITIES THROUGH IMPROVED DATA HANDLING TECHNIQUES

by

F. J. Kriegler
Infrared and Optics Division

∑ ENVIRONMENTAL
RESEARCH INSTITUTE
OF MICHIGAN

FORMERLY WILLOW RUN LABORATORIES.
THE UNIVERSITY OF MICHIGAN

prepared for

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

NOTICES

Technical Report

EXTENSION OF ERIM MULTISPECTRAL DATA PROCESSING CAPABILITIES THROUGH IMPROVED DATA HANDLING TECHNIQUES

by

F. J. Kriegler
Infrared and Optics Division

E N V I R O N M E N T A L
RESEARCH INSTITUTE
OF MICHIGAN

FORMERLY WILLOW RUN LABORATORIES.
THE UNIVERSITY OF MICHIGAN

prepared for

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

June 1973

NAS 9-9784 Task B2.11.2

Lyndon B. Johnson Space Center
Earth Observations Division
Houston, Texas

FOREWORD

This report describes part of a comprehensive and continuing program of re-
search into remote sensing of the environment from aircraft and satellites. The
research is being carried out for the NASA Manned Spacecraft Center, Houston,
Texas, by the Environmental Research Institute of Michigan (formerly the Willow
Run Laboratories, a unit of The University of Michigan's Institute of Science and
Technology). The basic objective of this multidisciplinary program is to develop
remote sensing as a practical tool to provide the planner and decision-maker with
extensive information quickly and economically.

Timely information from remote sensing will be important to such people as
the farmer, the city planner, the conservationist, and others concerned with a var-
iety of problems, such as crop yield and disease, urban land studies and develop-
ment, water pollution, and forest management. The scope of our program includes:
(1) extending the understanding of basic processes; (2) developing new applications,
advanced remote-sensing systems, and automatic data processing techniques to ex-
tract information in a useful form; and (3) assisting in data collection, processing,
and analysis, including material spectra and ground-truth verification.

The research described here was performed under NASA Contract NAS 9-9784,
Task B2.11.2, and covers the period from November 1, 1971 through January 31,
1973. Dr. A. Potter was Technical Monitor. The program was directed by R. R.
Legault, Associate Director of the Environmental Research Institute of Michigan,
and by J. D. Erickson, Principal Investigator and Head of the Multispectral Analy-
sis Section. The ERIM number for this report is 31650-158-T.

ACKNOWLEDGMENTS

ABSTRACT

The overall objective of the program described is to improve and extend the capabilities of the ERIM processing facility in handling multispectral data. Improvements consisted of implementing hardware modifications which permitted more rapid access to the recorded data through improved numbering and indexing of such data. In addition, techniques are discussed for handling data from sources other than the ERIM M-5 and M-7 scanner systems.

CONTENTS

FIGURES

EXTENSION OF ERIM MULTISPECTRAL DATA PROCESSING CAPABILITIES THROUGH IMPROVED DATA HANDLING TECHNIQUES

1

SUMMARY

This program to improve ERIM's multispectral data processing facilities began in November 1971 as an effort to construct or procure a hardware interface unit that would enable ERIM to handle 24-channel flight data tapes from scanners of MSDS type. (At that time ERIM's predecessor organization, WRL, had only 12-channel processing capabilities, geared to M-5 and M-7 scanners.)

An interface unit design effort was undertaken and, in March-May 1972, breadboard tests were run on critical portions of the hardware. The next steps would have been purchase of components followed by the start of in-house construction. Meanwhile it was found that Bendix Aerospace had a proven interface unit available at a competitive cost. A tentative order was placed. Before purchase order issuance, however, NASA/MSC decided to institute a substantial change in program direction.

The revised statement of work published to implement this change retained the original program objective — namely, more efficient and improved data handling facilities — but defined an alternative approach through five new hardware tasks. Under these tasks ERIM (at that time WRL) was to develop and add to existing processing equipment the following capabilities and features: (1) scan-line count recorded on flight data tape, (2) de-skew marker pulse recorded on video tracks of flight data tape, (3) scan-line count recorded on computer-compatible digital data tapes, (4) scan-line count recorded on film imagery, and (5) scan-line count control for the SPARC processor.

2
BACKGROUND

For some years the Environmental Research Institute of Michigan (ERIM), formerly the University of Michigan's Willow Run Laboratories, has developed and operated a large amount of hardware and software for handling and processing multispectral data [1, 2, 3]. The type of raw data input that ERIM can presently handle most efficiently corresponds in format to the data output of the ERIM-owned M-5 and M-7 scanners; as recorded on analog tape, this output has an information bandwidth of 20 kHz to 80 kHz and an information duty cycle of about 25%.

A quite different format is found in NASA's airborne Multispectral Data System (MSDS). NASA-MSDS output tapes are in a digital format, packed at 10^4 bits per inch on instrumentation tape, and coded with a bi-phase level code. Thus before data input into either a digital computer or an analog computer such as our existing SPARC processor [4], the MSDS tapes must be first decoded and reformatted.

Studies [5, 6] have stressed the need for a step-up in the speed, and thus the timeliness, of multispectral data processing in order to approach that rate at which the data were collected — that is, at real-time or near real-time rates. As these studies have shown, this cannot be done using a conventional digital computer. Nor can it be done if the data is stored on conventional computer-compatible tapes (CCTs), since the original flight tape's data rate is about 20 times higher than can be obtained from a CCT. Therefore, in order to handle or process data at anywhere near real-time rates, the data source should be the original flight tape or a suitable copy thereof.

However, by having an interface unit that could properly decode and reformat the data, ERIM could accomplish the processing at real-time rates through a processor such as the SPARC. Accordingly, ERIM proposed to design and construct a 24-channel interface unit that would permit efficient handling and processing, at ERIM, of data tapes generated by the MSDS, thereby avoiding the bottleneck of CCTs. This proposal was favorably considered and accepted by NASA/MSC. Design work began in late 1971 and had progressed into breadboard testing when it was stopped, in June 1972, by a sponsor decision to explore alternative possibilities.

3
DESIGN OF AN INTERFACE UNIT TO PROVIDE COMPATIBILITY WITH MSDS FLIGHT DATA TAPES

The design philosophy for the interface was to provide a piece of equipment that would provide MSDS output tape compatibility with ERIM's existing multispectral processing facilities. These facilities, which include a CDC-1604B digital computer, an IBM 7094 digital computer, and a special purpose analog processor —·the SPARC SPectral Analysis and Recognition Computer —could not, and cannot yet, handle multispectral data obtained in original format from the NASA/MSDS (Multispectral Data System) scanner.

To permit processing by our digital computer, the data must be converted from bi-phase level code to Non-Return-to-Zero (NRZ) data and packed into computer words for transfer into the digital machine. This means that for the CDC-1604 computer, the data must be packed into 48-bit words.

For processing on our analog computer, the data samples must be converted to analog form by means of high speed digital-to-analog converters. And because of the high bit-packing-density on the NASA/MSDS data tapes, special techniques are required to decode, synchronize, and de-skew the data. The special equipment necessary to implement these techniques would comprise a major portion of any interface unit used to read out data in any processing system using high density tapes as input.

The remainder of the interface unit requires hardware specially tailored to interface to the automatic data processing equipment described above. The entire system is block-diagrammed in Fig. 1.

Of this system, the bit synchronizer section of the interface was breadboarded and tested since it appeared to represent perhaps the most critical system element. A block diagram of the bit synchronizer is shown in Fig. 2. Its basic components are: a comparator to shape the bi-phase level signal coming from the tape recorder, a phase-locked loop to provide the instantaneous data rate (clock), and a digital comparator to decode the bi-phase signal to NRZ. The waveforms of the data at various locations in the bit synchronizer are shown in Fig. 3. This breadboard was successfully tested with actual MSDS flight data.

About a year before the start of the present contract, we had received a quote from Bendix Aerospace for the construction of an interface similar to one they had supplied earlier to MSC. This Bendix interface design was based on use of small scale integration electronic components, which made the cost of producing such an interface more than that of medium scale integration (MSI) components (which can be used extensively to reduce wiring costs). Therefore our 1971 proposal to NASA/MSC was based on using newly available MSI components.
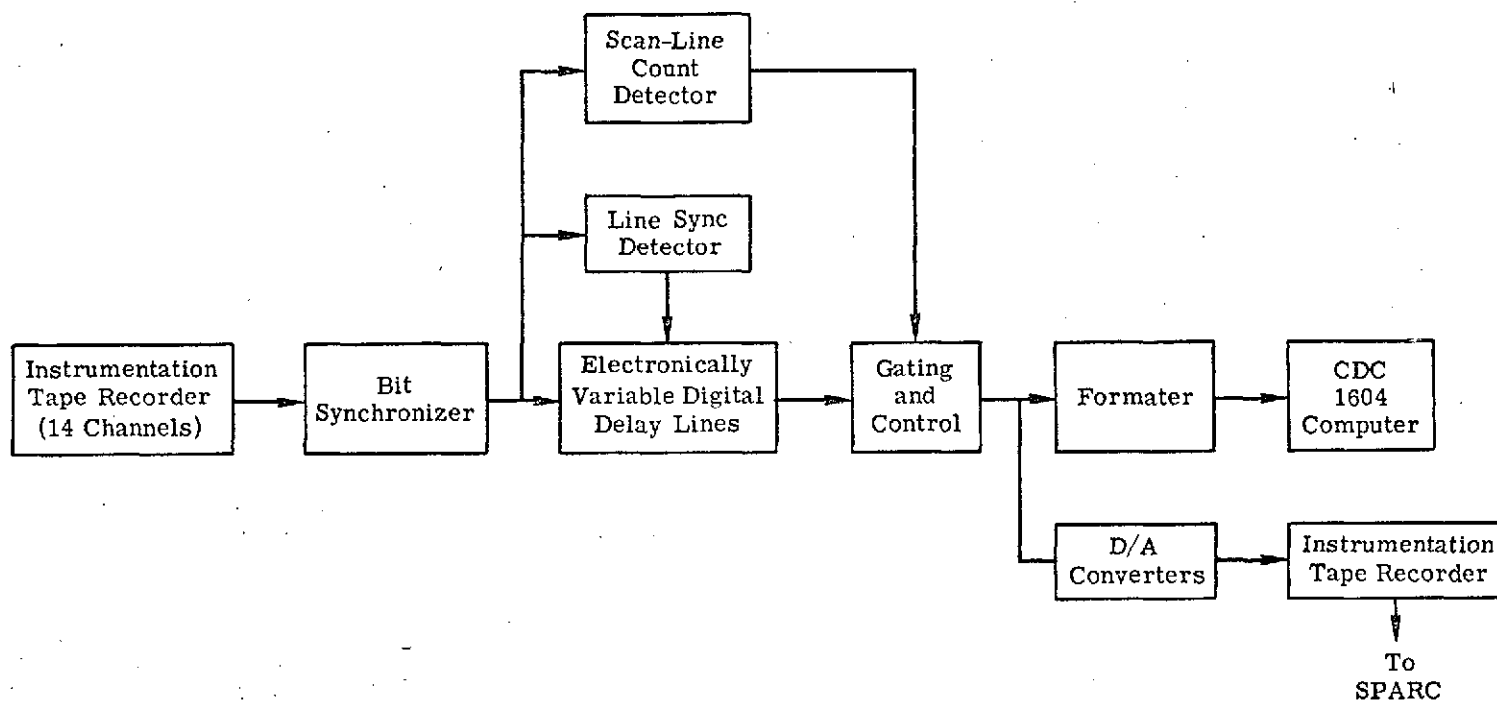
FIGURE 1. BLOCK DIAGRAM OF MSDS TAPE INTERFACE

4
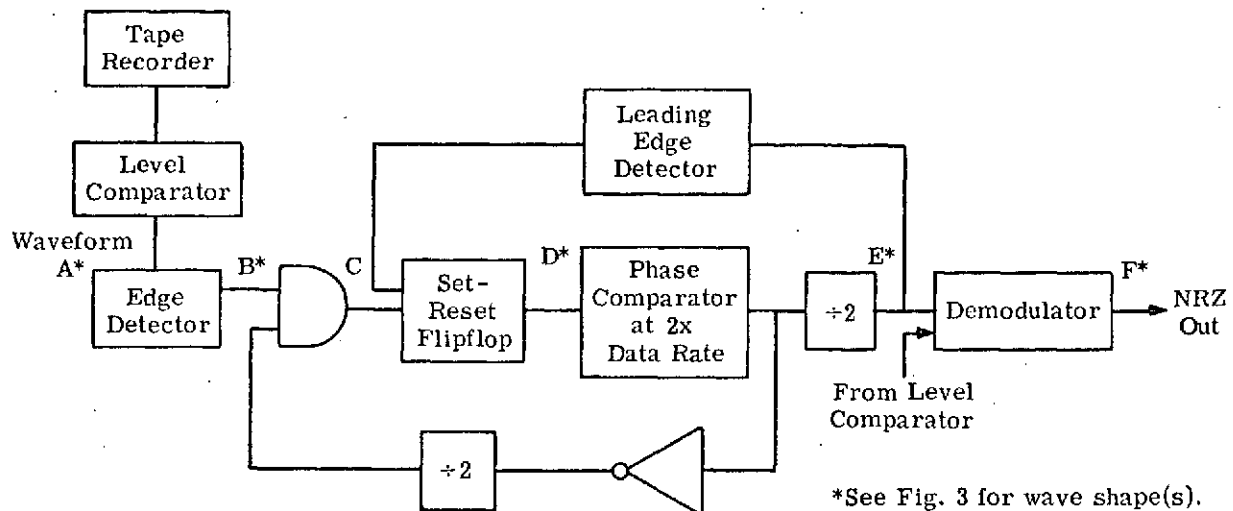
FIGURE 2. BLOCK DIAGRAM OF BIT SYNCHRONIZER AND DECODER
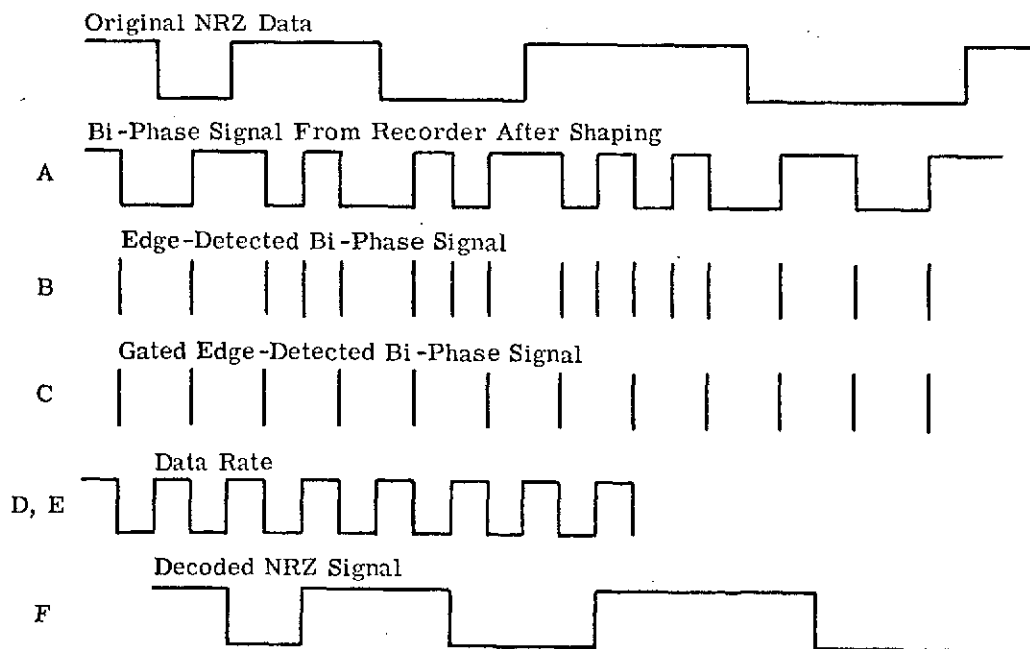
FIGURE 3. TYPICAL WAVEFORMS FOR BIT SYNCHRONIZER OPERATION

5

Our further discussions with Bendix in 1972 revealed that they too had redesigned the system to take advantage of the newer MSI electronic components. Also this later system was designed to interface to a Digital Equipment Corporation (DEC) PDP-11 computer, which happened to be the computer selected for incorporation into our SPARC/H Hybrid System currently under development. A new quote for their redesigned interface system was then obtained from Bendix; the price turned out to be close to one-third their original quote and quite comparable to our building the system in-house. Because this was a second-generation design with improved performance specifications, purchase of the interface from Bendix was decided upon.

The bit synchronizer-decoder described earlier, which was designed and built by Bendix, was tested at our Willow Run tape handling facility by connecting it to each of two tape recorders—an Ampex FR1900 and a Mincom PC-500. A previously obtained MSDS flight data tape was played back on these machines. The test unit was able to lock onto the bi-phase level signals and decode these signals as an NRZ-L signal. The test unit did not have a line sync decoder or a digital-to-analog converter, therefore generation of a video signal was not possible. A test had been scheduled to generate a video signal from the MSDS tape. Before this could be accomplished, however, a decision was reached that ERIM should try and achieve compatibility by upgrading and improving the capabilities and efficiency of existing MS data processing facilities. Therefore the purchase order for an MSDS data tape interface unit to be built by Bendix was not issued.

4
DESIGN AND CONSTRUCTION OF EQUIPMENT FOR IMPROVED DATA HANDLING

Early in the contract period discussions were held between ERIM and MSC personnel regarding the implementation of techniques for improving the efficiency of processing data obtained from the M-7 scanner. As a result of these discussions five proposed modifications to ERIM's multispectral processing facilities were specified. These modifications were to provide the capability to: (1) record scan-line count on flight data tapes, (2) provide scan-line count control on the SPARC processor, (3) record de-skew marker pulses on the flight data tapes, (4) produce scan-line count on film imagery, and (5) record scan-line count on digital tapes. Two of these modifications concern the aircraft equipment, one concerns the SPARC processor, another the film imagery printing facility, and one is applicable to our data conversion and duplicating facility.

These modifications, and the selection of a suitable instrumentation-quality tape recorder to replace one (a Mincom PC-500) loaned to ERIM by the Air Force, will now be individually discussed. (The present Mincom tape recorder is one of two machines used to make duplicate data tapes; since processing at ERIM is almost exclusively done with duplicate tapes, such a tape recorder is vital to the operation of our entire multispectral data processing facilities.)

4.1. SCAN-LINE COUNT ON FLIGHT DATA TAPES

To provide a reference for tape search and data screening in all applications of the original data, each scan of data must be uniquely numbered. These applications include tape to display, tape to tape, tape to digital computer, tape to film, and tape to the SPARC. Moreover, if the scanner operator is able to note the scan count when aircraft perturbations occur, a much better correlation can be obtained between the flight data and the aircraft flight log.

Prior to the present contract the scan-line count was added when tape copies ("dupes") of the original data were being made. Unfortunately, this method proved imprecise since uncertainties in the startup time of the airborne tape recorder resulted in an uncertain beginning of a run. As a result, supposed duplicate tapes were often found to have slightly different counts. This danger is best avoided by recording the line count directly on the original tapes.

A system for recording the scan-line numbers of the M-7 scanner concurrently with video signal recording has been designed and implemented. Scan-line number information, in the form of a 20-bit serially encoded word, is now recorded on the same track as the sync signals. These 20 bits represent 5 decimal digits in the conventional 8-4-2-1 BCD (Binary Coded Decimal) code. The line count recording system has the following characteristics.

7

(1) The code is of the return-to-zero type; i.e., the recorded zeros and ones are separated with a zero volt level. With this type of coding the clock is included with the data and can be extracted to decode the line number.

(2) A "one" is recorded on tape by a 1/2 volt positive pulse of 200 μsec duration, whereas a zero is represented by a negative 1/2 volt pulse of the same duration.

(3) The zero volt spacing between bits is 200 μsec.

(4) The line number word begins 1 msec after the roll sync. The most significant bit occurs in the bit stream first.

Figure 4a shows a typical recording of the sync channel; it includes the two sync signals (aircraft and roll) and the line count word that corresponds to that scan line. The negative sync pulse is the non-roll-stabilized sync of the scanner; the positive sync pulse just after the negative pulse is the roll-stabilized sync. The 20 bits ($\pm1/2$ volt) that follow the sync waveforms represent the scan-line number (in Fig. 4a the line number is 48,735).

Figure 5 presents a block diagram of the system that accumulates the line number and serially encodes this number on tape. The system operates as follows: The scanner sync is counted by a 5-digit BCD counter. At the trailing edge of the sync the contents of the counter are loaded into a 20-stage shift register. Approximately 1 msec after the roll-stabilized sync pulse, the shift cycle of the system commences. The shift clock interrogates the last shift register stage (most significant bit of the counter) and the status of the stage appears at the output of Amplifier A (see Fig. 5) as a 1/2 volt pulse of 200 μsec duration. The shift register is then shifted one clock pulse and interrogation of the last shift register state is performed again. Since the shift-interrogate clock is a 2 kHz square wave, the output waveform from the shift register is a 20-bit word of the return-to-zero type format in which each level is of 200 μsec duration.

The final amplifier (Amp A) adds the two sync signals and sends this output to the instrumentation tape recorder where it is recorded as sync channel information.

The hardware for recording the scan-line count on flight data tape was readily implemented during the 1972 data collection season since provision for this feature had been previously designed into the electronics.

The count display and count number preset feature was not implemented, however, since to do so requires modifying the control panel. Electronically, this implementation presents no problem (see dotted lines in Fig. 5). The main task is to modify the control panel and wiring harness on the aircraft; this can be done early in 1973 during the usual winter lull in data collection.
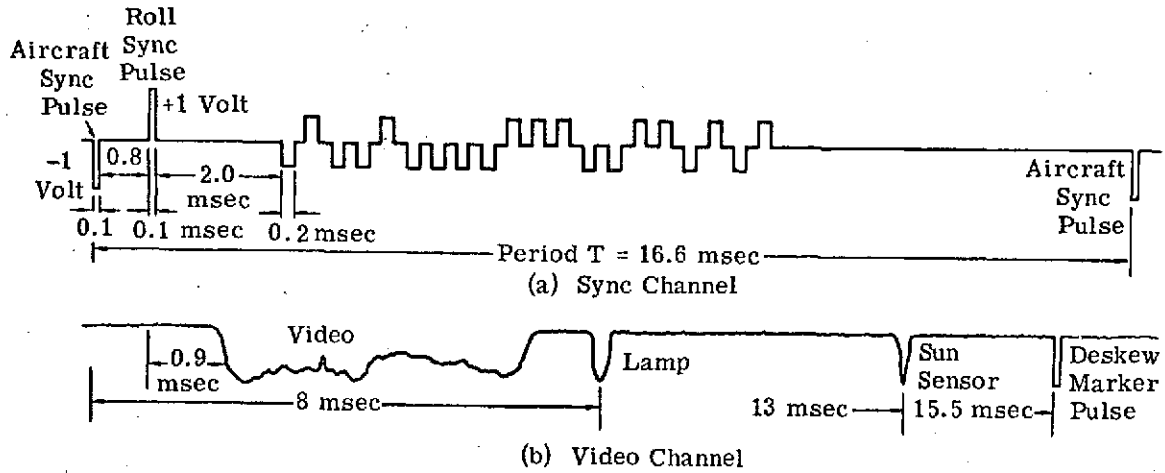
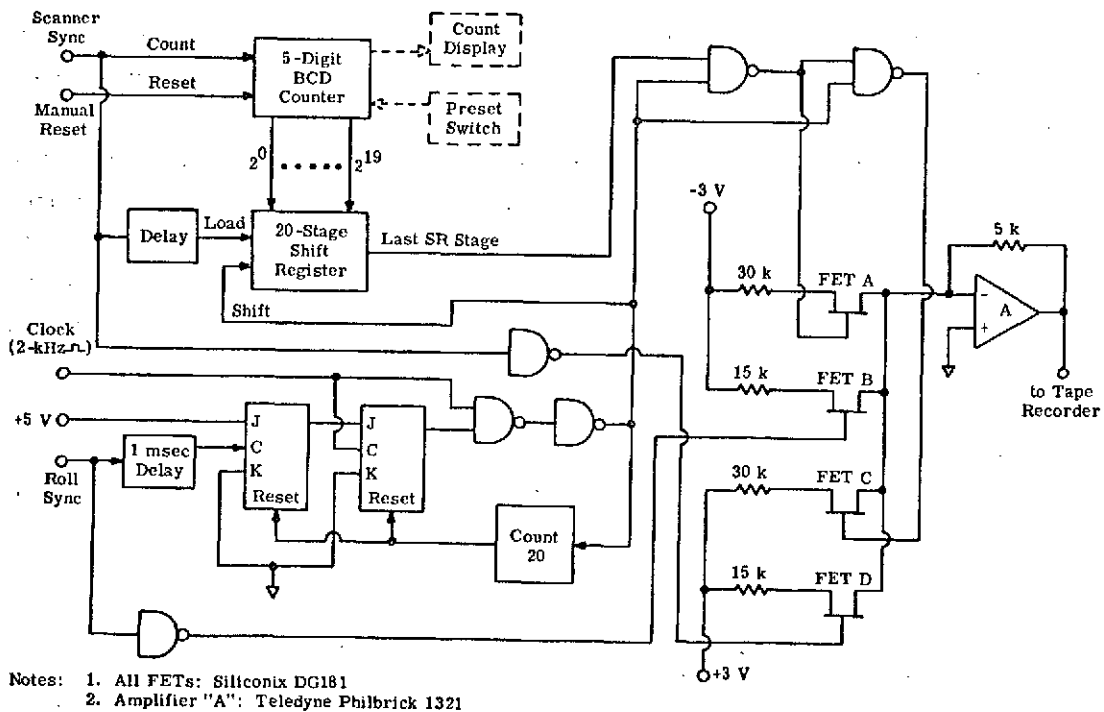FIGURE 4. ANALOG FLIGHT DATA TAPE FORMAT

Notes: 1. All FETs: Siliconix DG181
         2. Amplifier "A": Teledyne Philbrick 1321

FIGURE 5. BLOCK DIAGRAM OF LINE COUNT RECORDING SYSTEM

4.2. SCAN-LINE COUNT CONTROL ON SPARC PROCESSOR

To afford better control of analysis operations on the SPARC processor, we modified its spectral analysis subsystem so that the original scan-line count information could be decoded and displayed to the operator. This subsystem incorporates a tape loop with playback capability; its purpose is to permit the SPARC to perform spectral analysis on a gated area of video selected by the operator. Prior to the modification described herein, the video gating was not always repeatable. However, addition of the line-count control feature to the video gating subsystem gave the SPARC operator the precise control necessary to achieve true video gating repeatability in the analysis mode of operation. Another benefit of line count control lies in the improved accuracy with which area counts can be obtained over an entire run.

When the SPARC is operated in its recognition mode, the line count control can also be used to precisely define the start and end of a run, thus enabling accurate and repeatable area recognition counts. Film overlay placement can also be facilitated by printing a dark line across the film at the start and stop points of a run. (In the past some overlays proved difficult to position, particularly in those cases where some elements happen to be so sparsely distributed as to comprise only small recognition areas on the recognition map.)

A block diagram of the SPARC Line Count Control System is shown in Fig. 6. Line count from tape chan. 7 is detected by separate zeros and ones detectors; this count is in bipolar, return-to-zero form, as described in Section 4.1. Detector outputs are combined to form a clock train and ones are loaded into a shift register. Contents of the shift register are then displayed on a 5-digit segment display and also compared with preset command switches. The display indicates to the operator the current data line which, upon operator command, may be held on the display without stopping the tape recorder; this aids in setting the line count into the command switches. When coincidence with a command switch is found, appropriate outputs are generated. These outputs consist of one frame, two training gates, and a flash signal to the strip film printer. The flash signal, when selected, occurs at frame start and stop points; it is used to indicate the beginning and end of recognition pictures being produced on SPARC.

4.3. DE-SKEW MARKER PULSES ON FLIGHT DATA TAPES

When video signals from the multispectral scanner are recorded on an instrumentation tape recorder, some transport delays are introduced in the information channels; the effect of these delays is commonly known as skew.

We presently re-register (de-skew) the data when the tape is being duplicated for processing by first feeding the different video channels into variable delay lines. Using the sun sensor response from one of the video channels as a reference, we then adjust the delays so that the
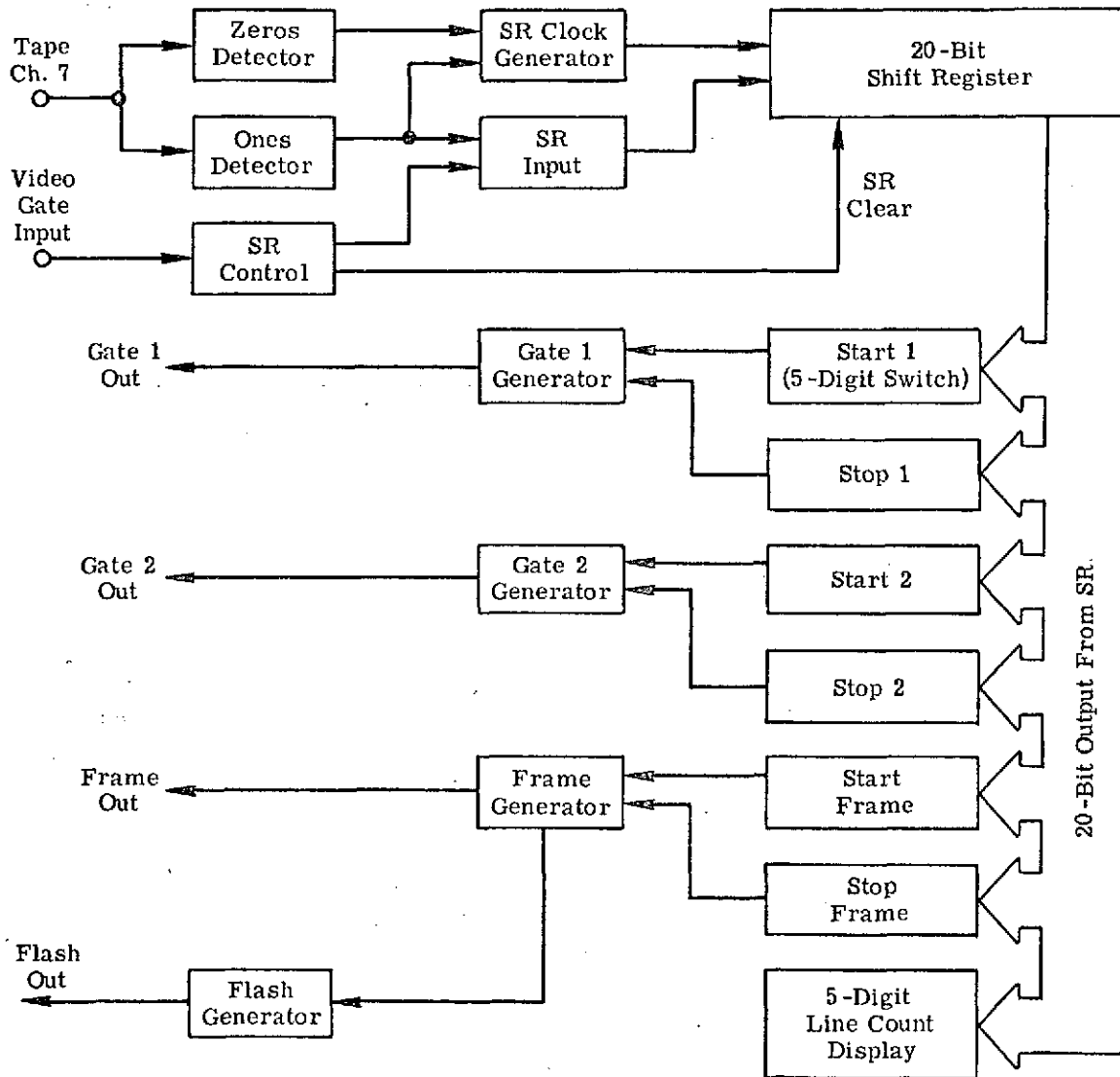
FIGURE 6. BLOCK DIAGRAM OF LINE COUNT CONTROL FOR THE SPARC SYSTEM

sun sensor responses of the other video channels are lined up. (The sun sensor response is recorded on all the video channels between the reference sources and the video.)

The drawback in using sun sensor response for channel alignment purposes is that the size of such response, as recorded on tape for each channel, is a function of the detector and the electronic gain of each particular channel. This can cause a wide discrepancy in the sizes and shapes of the sun sensor responses for different spectral channels, often making alignment ambiguous and sometimes impossible.

To overcome this problem we plan to inject, on each video track at the time the information is first recorded, a marker pulse for aligning the video channels. The format of the marker pulse is shown in Fig. 4b. This pulse, introduced after the channel gain, will have sharp edges (compatible with the video bandwidth) and a precision reference level. The design for generating and locating this reference (marker) pulse on all video channels has been completed. (See simplified diagram, Fig. 7.) Aircraft modifications necessary for circuit installation will be made during the winter lull in data collection. These marker pulses will allow the data to be measured, to about 1/10 of a resolution element in timing accuracy. After tape recording, however, the rapid timing variation in tape motion (dynamic skew) is expected to result in a channel-to-channel variation across the tape of about 1/4 resolution element.

4.4. SCAN-LINE COUNT RECORDED ON FILM IMAGERY

The scan-line count recorded on the original flight data tapes (described in Section 4.1) can also be recorded on strip film imagery. Typically, four channels of video are displayed on film and made available as soon as possible as part of each data collection flight. If an investigator looking at this imagery can accurately call out an area of interest by scan-line count, any handling or processing of that data will be facilitated since little if any search time will be required.

The format for recording line counts on film is depicted in Fig. 8. The count appears as short "tick" lines in the margin at the edge of the film. The short horizontal lines shown nearest the left-hand edge of the film in the figure will mark every 10th scan line; the next short lines (just to the right of the first column of markers) will mark every 100th line; and the third column of lines will mark every 1000th line.

At a scanner altitude of 1000 ft, the reproduced 70 mm film imagery is such that every 10th scan line marker is separated by about 1/30 of an inch in the direction of flight. For obvious reasons it is not desirable to put these pulses much closer together, which they would be for higher altitude imagery. Therefore, at altitudes between 1500 and 3000 ft, the marker ticks at the left-hand edge will represent every 20th scan line; between altitudes of 3000 to
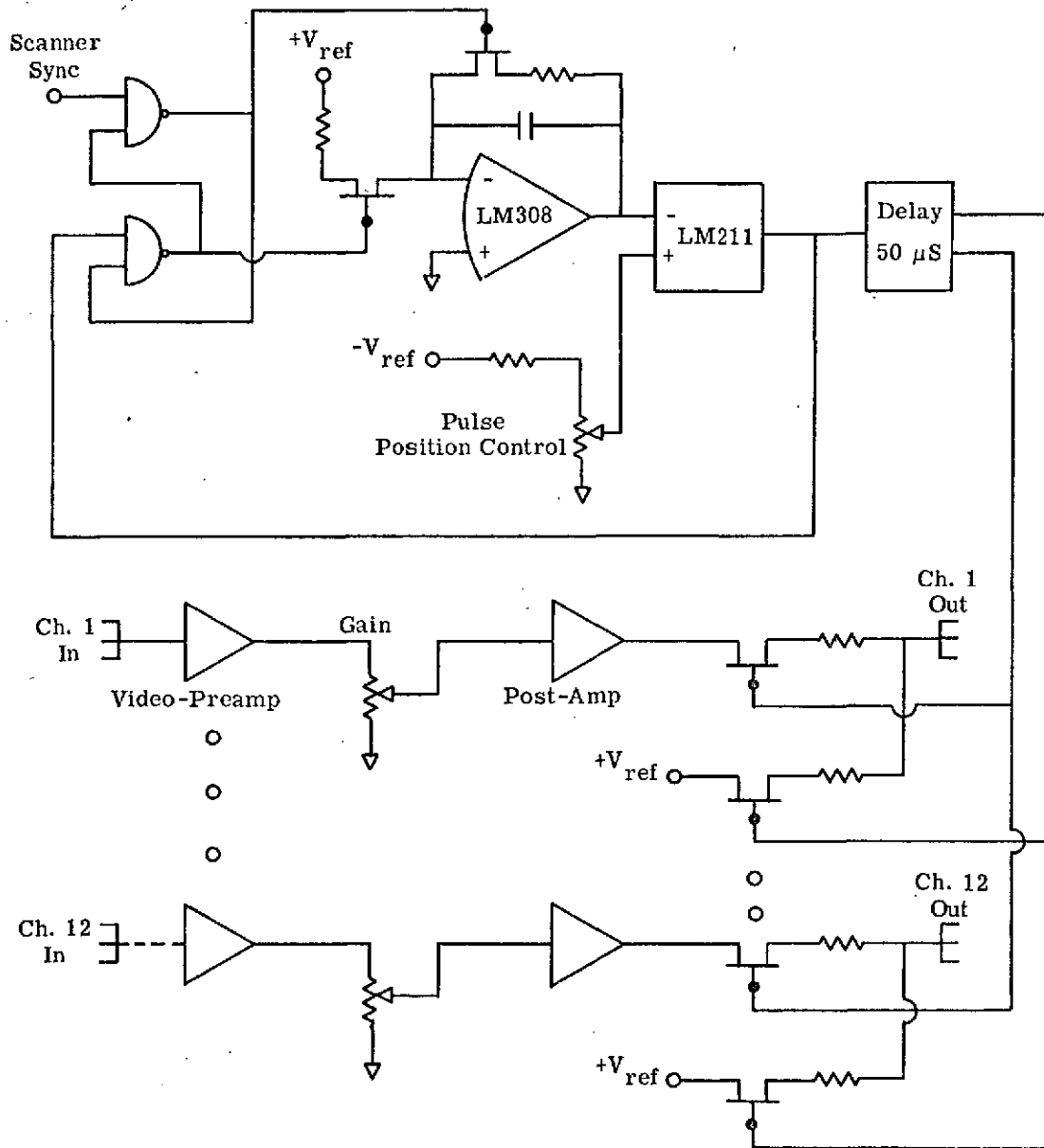
FIGURE 7. DIAGRAM OF DE-SKEW MARKER PULSE GENERATOR

ERIM

6000 ft, they will represent every 50th scan line; and over 6000 ft altitudes the same marker ticks will represent every 100th scan line.

In order to record the 10,000 line count without using up additional film width, the 1000 line marker will be broadened (in the direction of flight) when a change in the 10,000 line count occurs. This is also shown in Fig. 8. The 10,000 count integer may be found by closely examining the broadened 1000 marker and simply counting the number of contiguous marker pulses recorded in the adjacent 100th scan line marker column.

A block diagram of the system is shown in Fig. 9. The shift register is loaded with the line count. Digital comparators detect a "zero" on each of the digits. The 1's count controls the left-hand marker at every 10th, 20th, 50th or 100th marker. The 1's count along with the 10's count controls the middle marker at every 100th line when both the 1's and 10's digit is zero. The 1000 line marker is controlled in a similar manner. To produce and record the line segments representing the count, marker pulse waveforms are gated to the CRT in the strip film printer at the proper instant during the sweep.

To date, this system has not been implemented. We plan to do this during a planned shutdown of our film generation facility for maintenance; timing will coincide with the usual winter lull in data collection.

4.5. SCAN-LINE COUNT RECORDED ON COMPUTER-COMPATIBLE DIGITAL TAPES

The line count recorded on instrumentation tape can be transferred to digital tape in a straightforward manner. During the A to D conversion process, the digital (BCD) format of the line count lends itself to this transfer and need not be changed. During each scan, the line count is loaded into a 20-bit register and displayed at the beginning of the next scan. After display, the count can be transferred to a holding register for transfer to computer memory as a 48-bit computer word in the CDC-1604B computer. In subsequent conversion of this digital tape to standard ERIM format for the IBM-7094 computer, the scan-line count is stored in binary form in the second 36-bit word of the scan-line record. The scan-line record format is shown in Fig. 10.

4.6. INSTRUMENTATION TAPE RECORDER

An instrumentation tape recorder is needed as part of the ERIM data conversion and duplicating facility. After carefully testing and evaluating various machines, a Bell & Howell model was selected as optimal on the basis of compatibility with our existing facility. Discussions were held with sales representatives from various manufacturers, including Ampex, Bell & Howell, Honeywell, Mincom, and Sangamo.

The machines of two manufacturers (Mincom and Ampex) were quickly ruled out as being unsuitable for our application. The Mincom TICOR III was ruled out on the basis that it is primarily designed for the Wideband II type of recording and playback. Since we do not use

14

15

*b1,000

10's {

*bb,100

20,000

*b = a digit of unknown value

FIGURE 8. FORMAT FOR LINE COUNT ON
STRIP FILM IMAGERY

Shift Register

Line Count	10,000	1000	100	10	1

Zero Detector

Zero Detector

$\div 1$
$\div 2$
$\div 5$
$\div 10$

Zero Detector

Zero Detector

Strobe

Down Count   1000's   100's   10's

10-k Count

Line Sync   To CRT

Gates

FIGURE 9. BLOCK DIAGRAM OF CIRCUIT
FOR PRODUCING LINE COUNT ON FILM

WORD 1	WORD 2	WORD 3	WORD 4				WORD 8				

DIGITAL   SCAN
RECORD   LINE
  #   COUNT

MISCELLANEOUS SCAN LINE
INFORMATION

DIGITAL SCANNER
DATA

DIGITAL RECORD #   —incremental count of physical records within a data file (binary)
SCAN LINE COUNT   —line count from instrumentation tape (binary)
MISCELLANEOUS INFO—data related to a particular scan line (e.g., timing information, etc.)
DIGITAL SCANNER   —9-bit scanner data values —one per spectral channel, interleaved,
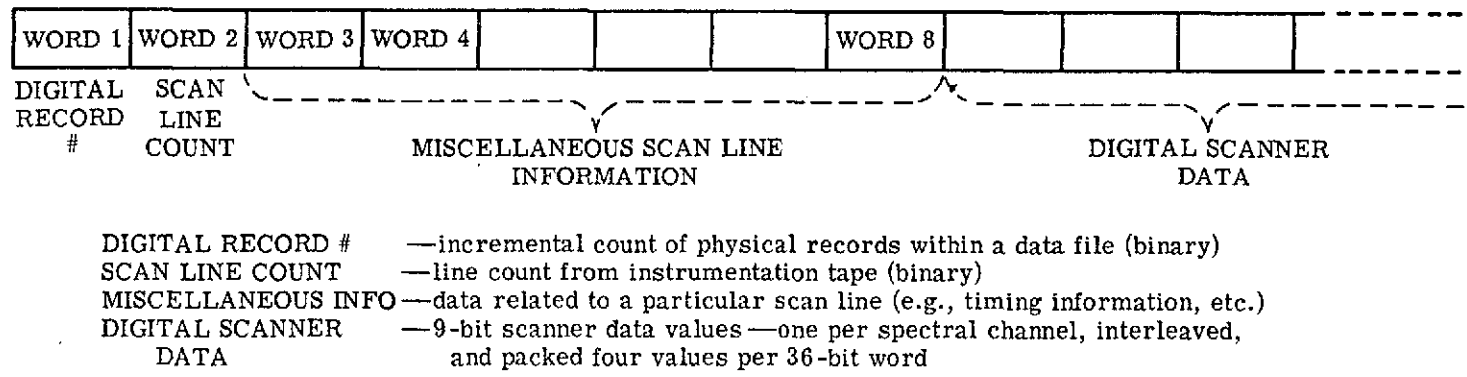   DATA   and packed four values per 36-bit word

FIGURE 10. DIGITAL DATA TAPE RECORD FORMAT

this extended bandwidth mode of operation it was felt that this machine would not be suitable for our purposes. Both the Ampex FR-1900 and the FR-2000 instrumentation tape recorders were ruled out on the basis of head wear. Our experience with an Ampex FR-1900 has revealed serious head wear problems, which Ampex acknowledges. At the time of purchase order issue, Ampex did not have a solution to this problem.

A demonstrator Honeywell 7600 tape recorder was brought into the lab and tested. The tests performed were not intended to verify the usually listed specifications but rather to show that this machine would function in some of the unusual conditions in which we operate. This machine was used first as the reproduce machine in tape duplication and secondly as the record machine in tape duplication. It performed very well in both roles. As the reproduce machine, it had an output signal somewhat larger than the borrowed Mincom PC-500 we have been using. But since our duplicating electronics incorporate wave-shapers that have diode clipping circuits, the magnitude of the signal beyond a minimum threshold is not too critical. A tape that was duplicated on the Ampex FR-1900, and which showed some breakup at 60 inches per sec (ips) tape speed when reproduced on the FR-1900, was then reproduced on the Honeywell 7600 at 60 ips. The demodulated signal was very clean. The Honeywell recorder also worked very well when used as the recorder in the duplicating process. (This indicates that our present wave-shaping electronics to drive the heads are adequate, although some small changes in level may be needed to optimize performance.)

The Honeywell recorder also has a good tape handling design. Vacuum chambers are very deep thus providing good isolation from reel disturbances and resulting in a reliable tape handler. There are no pinch rollers; instead, tape-wrap around the capstan provides the tape pulling force, just as in the Ampex FR-1900. Tape travel over the heads is conventional. A test measurement of dynamic skew showed it to be less than 2 msec between tracks 1 and 13, which is as good an any other manufacturer's specification.

A demonstrator Bell & Howell VR-3700B instrumentation tape recorder was also brought into the lab. Tests performed were the same as performed on the Honeywell tape recorder and results were essentially identical. Both machines appeared to be suitable choices.

Since a Sangamo Sabre VI machine was not available for testing, it was ruled out.

Our decision to purchase a Bell & Howell VR-3700B machine in preference to the Honeywell was based on the following reasons. The Honeywell 7600 is an old design with outdated electronics. Extensive use is made of electromechanical relays throughout the entire machine. Discussions with University of Michigan personnel who have been using a Honeywell 7600 for several years disclosed some problems in the power supplies and also with the vacuum system.

17

Therefore the more up-to-date electronics and simpler transport design of the Bell & Howell VR-3700B made it the top choice as the best available machine for purchase and use in the ERIM data conversion and duplicating facility.

5

‾CONCLUSIONS AND RECOMMENDATIONS

The innovation of recording scan-line count on original flight data tapes has definitely improved ERIM's capabilities to handle multispectral data more efficiently. In our frequent use of these line counts, we find that they permit much more rapid access to the data as well as complete repeatability on all re-entries. As an example, the SPARC processing operation previously required on the order of a day to prepare loops for training purposes. This has since been cut to less than 20 percent of the former time. It will again be cut sharply by having imagery with line count on it since training loops can then be called out without the former necessity of first previewing the data on a C-scan or CRT. Similarly, digital computer processing of the data can be made more efficient through use of line counts for rapid location and specification of training areas.

Compatibility between ERIM's data processing facility and external data sources such as MSDS, ERTS, and SKYLAB sensors is presently achieved by reading the data recorded on computer-compatible tapes (CCTs). Although this method of supplying data is satisfactory to most investigators, the SPARC processor can handle data rates about 20 times higher; for this reason ERIM could make good use of data sources offering a much higher data rate than CCTs.

At the outset of the present contract a prime task assignment was to build an interface unit capable of handling MSDS data in its original format as recorded aboard the aircraft, thereby permitting high data rates while avoiding the bottleneck of reformatting the data onto CCTs. Believing that the concept has merit and excellent potential, we therefore recommend that ERIM be re-authorized to obtain such an interface unit.

As a possible alternative to the MSDS interface recommendation, above, another approach toward realization of our multispectral data processing capabilities would be for ERIM to produce its own high density tapes from CCTs. By reading a CCT as fast as possible (in about 10 minutes) and recording the data on an instrumentation tape, a high density tape can be made. By then speeding this up by possibly a factor of 16 or 32, a data rate can be achieved commensurate with either the SPARC processing rate or that of the hybrid processor now under development. This approach, requiring only a minimum of hardware rather than the involved and expensive hardware needed to decode an original flight data tape from ERTS, MSDS or SKYLAB sensors, has the advantage of making ERIM's high-speed processing facility compatible with all data sources. Since all forms of sensor collected data can be made available in CCT format from the NASA-JSC production facility as well as ERTS, the production of high density tapes from CCTs appears to be the more attractive of the two approaches if either is pursued.

Accordingly, we recommend that the necessary hardware and recording device be procured
to enable ERIM to produce high density tapes for use in processing data at the higher rates of
which our facility is capable.

REFERENCES

1. "Investigation of Multispectral Discrimination Techniques," R. F. Nalepka, Report 2264-12-F, Willow Run Laboratories of the Institute of Science and Technology, The University of Michigan, Ann Arbor, January 1970.

2. "Investigations Related to Multispectral Imaging Systems for Remote Sensing," J. D. Erickson and F. Thomson, 31650-17-P, Willow Run Laboratories of the Institute of Science and Technology, The University of Michigan, Ann Arbor, September 1971.

3. J. D. Erickson, "Automatic Extraction of Information from Multispectral Scanner Data," Report 31650-139-J, delivered to 12th International Congress 1972 of the International Society for Photogrammetry, Ottawa, Canada, August 4, 1972, published in Archives, Volume 17.

4. F. Kriegler and M. Spencer, "A Statistical Spectral Analysis and Target Recognition Computer" (U), Final Report 8640-17-F, Willow Run Laboratories of the Institute of Science and Technology, The University of Michigan, Ann Arbor, September 1968, AD 392 744 (CONFIDENTIAL).

5. F. Kriegler and R. Marshall, "A Prototype Hybrid Multispectral Processor (SPARC/H) with High Throughput Capability," Report 31650-23-T, Willow Run Laboratories of the Institute of Science and Technology, The University of Michigan, Ann Arbor, March 1971.

6. R. Marshall and F. Kriegler, "Study of a Hybrid Multispectral Processor," Report 31650-154-T, Environmental Research Institute of Michigan, Ann Arbor, January 1973.